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APPLICATION OF LANDSAT-2 TO THE MANAGEMENT OF DELAWARE'S MARINE AND WETLAND RESOURCES

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A. PROBLEMS

LANDSAT-2 imagery, particularly CCT's were slow in reaching our team. However, this problem has recently been corrected.

Spring and summer LANDSAT passes over Delaware Bay had excessive cloud cover. Excellent overpasses were obtained in late summer and in the fall, with negligible cloud cover.

B. ACCOMPLISHMENTS

a. Coastal Zone Classification From Satellite Imagery

Studies of land cover distribution along Delaware's coast--especially in tidal wetland--have been made, utilizing semi-automated analysis of LANDSAT MSS digital data. Cover maps with eleven vegetation and other cover categories have been produced with accuracy of identification above 80% in all categories. Recent studies have tested a new technique for training automated analysis which uses ground measured reflectance and atmospheric correction techniques to derive signatures for specific categories in preference to the relative radiance signatures derived from training sets within the LANDSAT data itself. Intial tests using a four category scheme indicate that training data based on absolute measured reflectance and atmospheric correction of LANDSAT data can produce comparable accuracy of categorization to that achieved using more conventional relative radiance training. The analysis of the same four categories produced average categorization accuracies of 82.1% by conventional relative radiance training and 81.9% by use of absolute reflectance signatures. It is believed that refinement of the absolute reflectance training technique may provide better results in the future. Regardless, the absolute reflectance training combined with atmospheric

correction of scanner data provides a much more precise and better controlled data base which can be used to identify and assess promising uses of spectral discrimination in any area studied. Field results, suggest, for instance, that the height of Spartina alterniflora may, to some extent, be detectable and that early winter imagery may provide optimal spectral differentiation of several wetlands cover types.

b. Application of LANDSAT to Identify Potential On-shore Impact of Outer Continental Shelf Development

LANDSAT-2 imagery is being used together with maps, aircraft photographs, census data and socio-economic information to compare the coastal development of the Mid-Atlantic Region with the OCS petroleum industry intensive areas along the Louisiana coast; frontier areas such as Cook Inlet and Kenai Peninsula of Alaska; and contained conflict areas such as Santa Barbara, Ventura and Carpinteria, California. The identification of potential on-shore impact of Outer Continental Shelf activity is a pressing problem, since plans exist for extensive lease sales for OCS lands continuously during the next five to ten years and are certain to influence both coastal and second tier counties in most areas. Studies done by the University of Delaware on the use of remote sensing for evaluating land-use change have resulted in the ability to closely relate remotely observed land-use patterns with parameters that describe economic and social development.

c. Spectral Reflectance Signatures of Coastal Pollutants

Remote sensing from satellites and aircraft has been combined with ground truth collected from ships in an attempt to classify coastal and estuarine water types by their spectral reflectance signatures. In addition to other field experiments, during one ocean waste disposal operation 40 miles off the Delaware coast, water samples were collected and

spectroradiometric measurements conducted in the field to provide ground truth for aircraft and LANDSAT overpasses with multispectral scanners. Ground truth data are being correlated with multispectral data obtained remotely to define spectral signature tolerances due to variations in concentration and environmental conditions.

d. Verification by Remote Sensing of an Oil Slick Movement Prediction Model

LANDSAT, aircraft, ships and air-dropped current drogues have been deployed to determine current circulation and to track oil slick movement on four different dates in Delaware Bay. The results were used to verify a predictive model for oil slick movement and dispersion. The model predicts the behavior of oil slicks given their size, location, tidal stage (current), weather (wind) and nature of crude. Both LANDSAT satellites provided valuable data on gross circulation patterns and convergent coastal fronts which by capturing oil slicks significatnly influence their movement and dispersion.

C. SIGNIFICANT RESULTS

a. Studies of Current Circulation at Ocean Waste Disposal Sites

The following significant results were obtained using an integrated LANDSAT-aircraft-drogue technique to study current circulation at the duPont ocean waste disposal site, 40 miles off the Delaware Coast:

1. The duPont waste plume has been observed in 12 NASA/LANDSAT satellite images during dump up to 54 hours after dump. Wind, wave and current data are presently being analyzed to determine their effect on the dispersion and movement of ocean waste plumes.
2. The circulation processes at the acid waste disposal site are highly event-dominated, with the majority of the water transport

occurring during strong northeasters. During one such storm from January 21 to January 31, the drogues first moved to within 20 miles of the shoreline, then moved 80 miles off the coast, reaching speeds up to 3 knots.

3. There is a mean flow to the south alongshore. This appears to be due to the fact that northeasterly winds produce stronger currents than those driven by southeasterly winds and by the thermohaline circulation.

4. During the warm months (May through October), the ocean stratifies with warm water over cold water. A distinct thermocline was observed with expendable bathythermographs during all summer cruises at depths ranging from 10 to 21 meters.

5. During stratified conditions the near-bottom drogues showed very little movement. Surface currents responded to wind conditions resulting in rapid movement of surface drogues on windy days. Mid-depth drogues showed an intermediate behavior, moving more rapidly as wind velocities increased.

b. <u>The Influcence of Coastal Fronts on the Movement and Dispersion of Oil Slicks</u>

LANDSAT, aircraft and boats have been used successfully to study estuarine and coastal fronts or boundaries. Fronts (regions of high horizontal density gradient with associated horizontal convergence) are a major hydrographic feature in Delaware Bay and in other estuaries. Horizontal salinity gradients of 4‰ in one meter and convergence velocities of the order of 0.1 k/sec have been observed. Visibility improved from one meter to two meters as certain boundaries were crossed. Fronts near the mouth of the bay are associated with the tidal exchange with shelf water. The formation of fronts in the interior of the bay appears to be

associated with velocity shears induced by differences in bottom topography with horizontal density difference in the deep water portion of the estuary. Surface slicks and foam collected at frontal convergence zones near boundaries were found to contain concentrations of Cr, Cu, Fe, Hg, Pb, and Zn higher by two to four orders of magnitude than concentrations in mean ocean water.

By capturing and holding oil slicks, these frontal systems also significantly influence the movement and dispersion of oil slicks in Delaware Bay. Recent oil slick tracking experiments conducted to verify a predictive oil dispersion and movement model have shown that during certain parts of the tidal cycle the oil slicks tend to line up along boundaries. Thus, unexpected oil slick distribution patterns result which even for a known oil type cannot be predicted on the basis of wind and tidal current information alone.

D. PUBLICATIONS

1. Klemas, V. Invited presentation to Captain Jacques Cousteau and Dr. Philippe Cousteau on Ocean Current Measurement with Integrated Drogue-Aircraft-Satellite Systems, NASA Headquarters, Washington, D. C., October 6, 1975.

2. Klemas, V., Bartlett, D., Rogers, R. Coastal Zone Classification from Satellite Imagery. Photogrammetric Engineering and Remote Sensing, Journal of the American Society of Photogrammtry, Vol. 41, No. 3, April, 1975.

3. Klemas, V., Otley, M., Wethe, C., Rogers, R. ERTS-1 Studies of Coastal Water Turbidity and Current Circulation, American Geophysical Union 55th Annual Meeting, Washington, D.C., April 8-12, 1974.

4. Klemas, V., Tornatore, G., Whelan, W. A New Current Drogue for Monitoring Shelf Circulation, American Gelophsical Union 56th Annual Meeting, Washington, D. C., June 16-20, 1975.

5. Klemas, V and Bartlett, D. Application of ERTS-1 and Skylab to Coastal Zone Management, NASA Earth Resources Survey Symposium, Houston, June 8-13, 1975.

6. Klemas V., Davis, G., Wang, H., Whelan, W., Tornator, G. A Cost-Effective Satellite-Aircraft-Drogue Approach for Studying Estuarine Circulation and Shelf Waste Dispersion. Proceedings Ocean 75 Conference, San Diego, 1974.

7. Klemas, V., Davis,g., Wang, H., Whelan, W. Monitoring Estuarine Circulation and Ocean Waste Dispersion Using Integrated Satellite-Aircraft-Drogue Approach, International Conference on Environmental Sensing and Assessment, Las Vegas, September 14-19, 1975.

8. Klemas, V. Remote Sensing of Wetlands Vegetation and Estuarine Water Properties. Proceedings Third International Estuarine Research Conference, Galveston, October 6-9, 1975. (Invited Paper).

E. RECOMMENDATIONS

Make more attempts to obtain LANDSAT MSS imagery in the high-gain mode to enchance water features (suspended sediment, etc.).

F. FUNDS

On schedule.

G. DATA USE

Only several LANDSAT-2 tapes have been received so far. They will be evaluated during the next reporting period. LANDSAT-2 photographic products are used frequently within their range of utility.

H. AIRCRAFT DATA

Aircraft overflights have been on time and/or target. Imagery is on order and will be evaluated during the next three months.

I. PERSONNEL CHANGES

None.